A workshop concerning tropospheric measurements necessary for validation of observations from the Aura platform was held at CSC Greenbelt MD January 28-29, 2002. Participants agreed upon a strategy to develop an integrated plan for scientific progress in the troposphere and stratosphere in the next decade. The integrated plan will articulate science goals, and explain how these goals can be met with observations from the Aura spacecraft (and other space based platforms) in conjunction with observations from field campaigns. The field campaigns will provide independent observations from in situ and remote sensors that will be used both to meet the science goals of the particular campaign and for validation of the satellite data sets. The Aura observations will contribute to the science questions associated with the field campaigns by providing a larger scale context. The workshop opened with a review of the Aura platform capabilities (Douglass) and a statement of the requirements of NASA HQ that the validation observations for Aura be integrated with the science strategy for both the Aura platform and planned field campaigns (Logan). Froidevaux presented a summary of the Aura validation needs for tropospheric observations taken largely from Version 1 of the Aura Validation Document (available from the Aura web site). This presentation emphasized the capabilities and needs of the Microwave Limb Sounder (MLS) and the High Resolution Dynamics Limb Sounder (HIRDLS). MLS and HIRDLS will make most of their observations in the stratosphere. MLS brings the unique capability of measurements of upper tropospheric water vapor in the presence of clouds. HIRDLS will provide profiles of a number of important constituents down to about 5 km with 1 km vertical resolution, but only when the limb line of sight is cloud free. The Tropospheric Emission Sounder (TES) and the Ozone Monitoring Instrument (OMI) will provide information including the lower troposphere. TES will provide constituent profiles in a nadir and limb mode (Sander). Validation of the TES data requires observations in a range of regions and conditions corresponding to situations with significantly different averaging kernels, as discussed in Aura Validation Document. The importance of surface emissivity and reflectivity data in the 3-16 micron range, even at low resolution, for differing landscapes (e.g. ocean, ice, forest, grassland) was emphasized later in the meeting (Beer). OMI column measurements have a 13 x 24 km2 footprint within a large swath, and will provide daily global coverage (Brinksma). Profiles of NO2, O3 and aerosols are needed in clean and polluted areas to validate OMI fields of the tropospheric columns of O3 and NO2.

The next airborne mission of the Global Tropospheric Experiment (GTE) is the Intercontinental Chemical Transport Experiment (INTEX). The two phases of INTEX are planned for summer 2004 and spring 2006; it will be possible to plan flights to provide profiles that are close to coincident with satellite overpasses as part of these missions (Singh). The Tropical Composition and Climate Coupling Experiment (TC3) is proposed as a series of small missions taking place over several years at different locations during different seasons to explore processes controlling the composition of the upper tropical troposphere, emphasizing the physical mechanisms that control humidity there and in the stratosphere (Waugh). The TRACE P mission is a precedent for combining validation with an airborne experiment (Jacob). Flight segments for TRACE P included measurements of profiles of tropospheric CO to provide validation for space based data from MOPITT (Measurements of Pollution in The Troposphere), an instrument on the EOS Terra satellite). MOPITT validation also included bi-weekly aircraft measurements to 7 km from 5 sites, and data from SAFARI 2000 (Novelli).

Other practical aspects of mission planning include matching the type of platform required to make observations throughout the troposphere with the instruments available for each platform and with the validation needs of the satellite program. Plans must address a number of concerns: 1) inter-comparison of aircraft instruments for selected species; 2) any calibration issues; 3) technological advances that are feasible by 2005 that will make it possible to downsize instruments, and hence to utilize smaller platforms); 4) needs for new instrument development (Brune). New techniques for instruments include thermal dissociation combined with laser induced fluorescence for measurements of NO2, HNO3, total PANs and total alkylnitrates (Cohen) and Cavity Ring Down Absorption Spectroscopy which could be developed to measure a large suite of constituents in an instrument that would meet size and mass specifications for a Citation size aircraft (Anderson). The need to link in situ observations with a remote instrument like a lidar was stressed; development work is needed to develop a compact lidar system that could be used in an autonomous mode on an aircraft such as the WB-57 (Browell).

The West African Monsoon Experiment (WAM) is being planned for 2005 under European Leadership (France, UK), with collaboration from National Center for Atmospheric Research (NCAR) (Jacob). Observations of the seasonal variation in tropospheric ozone derived from aircraft profiles are in good agreement with 3-D model results, with a maximum in early spring associated with emissions from biomass burning. However, the tropospheric column derived from TOMS does not agree with either the in-situ data or the models in West Africa. TOMS tropospheric columns agree with sonde profiles and with the modeled effects of biomass burning in other regions. West Africa is also strongly influenced by Saharan dust, particularly in summer. Detailed measurements of ozone, ozone precursors and aerosols in this region would provide valuable data for validation of OMI and TES observations and would provide insight into the mechanisms controlling tropospheric ozone.

Measurements made from smaller aircraft may also contribute to Aura validation (Doddridge). In polluted conditions the total column of constituents such as NO2 is controlled by the pollutant sources and the meteorology of the tropospheric boundary layer. Measurements between the surface and 3 km are routinely made in small geographic areas. Sites such as College Park Maryland are often polluted. Surface measurements are also made routinely at several "elevated sites" located above the boundary layer. Both the aircraft and surface Observations are made often. Utilization of such observations by the satellite program is of mutual interest to the investigators (mostly funded by EPA?) and to the Aura investigators

The challenge to this workshop was to develop a framework in which to plan aircraft missions that would meet science goals and provide validation measurements for the Aura instruments. The mission science goals would complement the overall Aura science goals and be complemented by the Aura measurements. Newman and Friedl presented an umbrella program AVE (Aura Validation Experiment) that would rely on frequent deployments of the WB-57. Deployments could be as often as alternate months (6 per year, 20 flight hours, 120 flight hours per year), or a combination that included at least 4 deployments per year (120 total flight hours). The WB-57 is capable of providing profiles between the 1 and 19 km. AVE would take advantage of the pallets that carry experiments on the WB-57 and make it possible to deploy a standard payload with minimum effort. Specialized payload augmentations would likely be required to meet specific tropospheric science goals. The AVE deployments would constitute missions such as TC3 and would complement missions such as INTEX and WAM that require other platforms and instrumentation.

This workshop took significant steps towards development of an integrated science plan. The take home assignments from this workshop include weaving the threads of continuity and synergy between AVE and the named missions to which AVE would contribute into the fabric of the science plan. The need for frequent deployments during a 2 to 3 year period must be justified specifically. The science plan should include the science goals and a deployment schedule, and should address other issues such as payload requirements and development needs and the role of other platforms. A draft of this plan is anticipated by the March 19-20 Validation Meeting in Pasadena.